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PROTECTION OF THE ATMOSPHERE: TRANSBOUNDARY AIR POLLUTION

Report of the Secretary-General of the Conference

I. INTRODUCTION

1. This report was prepared in response to decision 1/13 of the first session of the Preparatory Committee for the United Nations Conference on Environment and Development, requesting the Secretary-General to prepare for the third session of the Preparatory Committee a report on the subject of transboundary air pollution, stressing that international co-operation was needed to enable developing countries to effectively monitor and assess transboundary air pollution (A/45/46, Annex I).

2. Preparation of this report benefited from contributions and comments by several United Nations bodies and specialized Agencies (in particular, the United Nations Environment Programme; the United Nations Economic Commissions for Africa, Europe, Latin America and the Caribbean; the World Health Organization; and the World Meteorological Organization) as well as independent experts participating in the UNCED secretariat's Working Party on the Atmosphere.

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3. In the light of discussions at the second session of the Preparatory Committee, indicating a concern shared by many delegations over problems of urban atmospheric pollution, UNEP and WHO agreed to provide a summary note on this issue, which is attached as an annex to the present report.

4. Pending a detailed discussion of the topic of transboundary air pollution at the third session of the Preparatory Committee, the cross-sectoral linkages and specific options for action arising from the present document remain to be incorporated in the overview document on "Protection of the atmosphere: options for agenda 21" (A/CONF.151/PC/42/Add.1).

II. BACKGROUND

5. The atmosphere of the Earth is both a reservoir, or receptacle, for many of the bi-products of human activity, and a pathway by which these materials make their way from industrial and other sources to the oceans, to the biosphere, and to humans. As in the case of the "greenhouse gases", long-lived pollutants injected into the atmosphere may sufficiently alter its properties and behaviour to have significant adverse effects on human health and environmental well-being. For other pollutants such as acidifying emissions or toxic organic chemicals, the atmosphere serves as the delivery mechanism to deposit them to sensitive parts of the ecosystem.

6. The perception of atmospheric pollution has evolved from that of a local issue (mainly connected with urban/industrial point-sources) to one of regional dimensions (associated with the long-range dispersion of acid precipitation and photochemical oxidants), eventually contributing to global problems of long-term climatic change. In addition to these "chronic" concerns that are shared by virtually all countries and the most remote areas of the Earth, there is a growing risk of "acute" man-made air pollution emergencies, the impacts of which may again transcend national boundaries: from recurrent seasonal smog alerts and major industrial accidents (such as the lethal Seveso, Bhopal and Chernobyl clouds) to the war-related burning of oilwells in Kuwait.

7. While environmental damage by transfrontier air pollution in Europe and North America is now abundantly documented, there still is insufficient information on the situation in other parts of the world. A 1988 study by UNEP and the International Council of Scientific Unions (ICSU) has identified southern China and other areas of southeast Asia, southwestern India, equatorial Africa including Nigeria, southeastern Brazil, and northern Venezuela, as being areas of probable sensitivity to soil and surface water acidification caused by long-range air pollution. The United Nations Economic Commission for Africa reports substantial levels of air pollution in the Zambian copper mining belt, from the discharge of sulphur dioxide and nitrogen oxides resulting in the formation of acid rains which may fall across the borders to neighbouring countries; specific cases resulting in the formation of smog from nickel mining activities have been observed in Zimbabwe and Angola; and extensive industrial activities in the Republic of South Africa are considered a possible source of transboundary air pollution in that sub-region.

Effects

8. According to a 1990 report prepared by the WHO Regional Office for Europe in the context of the Convention on Long-range Transboundary Air Pollution, "millions of Europeans live in areas with air pollution severe enough to cause each year thousands of premature deaths and many more chronically ill and disabled". The four characteristic pollution situations identified by the report are: summer-type peak concentrations or "episodes" (with photochemical oxidents being predominant); winter-type episodes (with sulphur dioxide and suspended particulate matter dominant); long-term exposure in urban areas to high levels of air pollution; and long-term multimedia exposure. Direct health effects of these situations are well documented and include increased respiratory symptoms, morbidity and mortality as well as increased cancer mortality. Indirect health effects include deteriorating quality of drinking water as a result of acidification and nitrification. As shown in the annex, far less information is available on comparable health risks in developing countries, largely because of a severe lack of data.

9. The effects of long-range air pollution on forests in 25 countries in Eastern and Western Europe have since 1986 been monitored by annual surveys under a joint project by UNEP and the United Nations Economic Commission for Europe, based on harmonized methods and joint training programmes developed in the context of the Convention on Long-range Transboundary Air Pollution. Other joint programmes under the Convention monitor the effects of air pollution on agricultural crops (28 laboratories in 18 countries); the acidification of rivers and lakes (16 countries); and atmospheric corrosion damage caused to materials, including historic monuments and modern industrial structures and coatings (at 39 monitoring sites in 14 countries). No comparable monitoring and assessment programmes exist for regions outside Europe and North America.

10. The Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP, sponsored by IMO, FAO, UNESCO, WMO, WHO, IAEA, UN and UNEP) has carried out several assessments of the interchange of pollutants between the atmosphere and the oceans. In view of the high share of long-range atmospheric inputs to marine pollution, regional monitoring programmes have been initiated for airborne pollutants in the North Sea, the Baltic and the Mediterranean. Efforts are underway to establish an Arctic Monitoring and Assessment Programme (AMAP), and further regional programmes have been proposed to monitor airborne pollution inputs to the Wider Caribbean and the Southwest Pacific regions.

Monitoring networks and emission inventories

11. The European/North American region is the only area for which a reliable time series of data and computer calculations on the transfrontier dispersion of air pollutants exists. The Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), established in 1977, provides Governments with information on the deposition and concentration of air pollutants, as well as on the quantity and significance of long-range transmission of pollutants and fluxes across boundaries. The EMEP programme regularly collects emission data, measures air

and precipitation quality, and models the atmospheric dispersion of pollutants. The sampling network consists of more than 100 monitoring stations in 24 countries, based on 24-hour sampling of air and precipitation. The EMEP fifth-phase programme (1990-1992) includes gas/particles measurements of SO_2, SO_4, NO_2, O_3, NO_3, NH_3, NH_4, HNO_3, and precipitation measurements of pH/H+, SO_4, NO_3, NH_4, Ca, K, Cl, Na, Mg and conductivity; to be extended in the future to hydrocarbons, photochemical oxidants other than ozone, and airborne heavy metals. A joint project by WMO, IAEA and the European Community initiated in 1989 (ATMES) evaluates atmospheric transport models for radio-nuclides in the European region, mainly with a view to improving preparedness and response to accidental releases.

12. The global WMO Background Air Pollution Monitoring Network (BAPMoN) has traced long-range transboundary air pollution since 1968 and has provided most of the atmospheric data to the UNEP Global Environment Monitoring System (GEMS). Together with the Global Ozone Observing System, it is now part of the WMO Global Atmosphere Watch (GAW), which operates a network of 337 station in 78 countries altogether. However, the geographical distribution of these stations is uneven, with the third world severely under-represented, as shown in the following table:

Number of GAW stations in operation as at 31 December 1990
by parameter and WMO Region

Parameters measured	WMO Region							All Regions
	Africa	Asia	S. America	N.& C. America	SW Pacific	Europe	Antarctica	
Precipitation chemistry	14	17	7	41	14	74	1	168
Particles	8	5	2	11	20	33	1	80
Sulphur dioxide	1	1	1	–	2	28	–	31
Turbidity	15	17	5	26	7	30	1	101
Oxides of Nitrogen	–	–	–	–	1	20	1	22
Carbon monoxide	–	–	–	–	2	–	–	2
Carbon dioxide	4	1	1	14	6	12	2	40
Ozone	9	43	5	17	11	49	7	141
Chlorofluoro-carbons	–	1	–	1	2	–	1	5
Radioactivity	1	–	1	–	3	2	2	8
Heavy metals	–	–	–	–	–	4	–	4
Ammonia	–	–	–	–	–	2	–	2
Nitric acid	–	–	–	–	–	2	–	2
Nitrous oxide	–	1	–	1	3	–	1	6

Parameters measured	WMO Region Africa	Asia	S. America	N.& C. America	SW Pacific	Europe	Antarctica	All Regions
Methane	-	-	-	1	3	1	1	6
Solar radiation	-	1	2	1	3	-	1	8
Other (incl. meteorology)	-	-	-	1	3	-	1	5
NUMBER OF STATIONS* all parameters	27	56	13	80	37	116	8	337

*Not the sum of the stations measuring the various parameters, as several parameters may be measured at a given station.

13. Detailed emission inventories and projections are essential for accurate model simulation of the transboundary dispersion and deposition of air pollutants. While existing mathematical models could be adapted for different regions of the world as well as for inter-regional and global modelling, the lack of reliable emissions data outside Europe and North America is a major constraint. Efforts are now underway to develop global inventories under an atmospheric chemistry project within the International Geosphere-Biosphere Programme of the International Council of Scientific Unions (ICSU). With regard to greenhouse gases, the Intergovernmental Panel on Climate Change (IPCC) has endorsed a workplan for the development of guidelines on national emission inventories, following an initiative by the Organisation for Economic Co-operation and Development (OECD).

Abatement technology and costs

14. Combustion of fossil fuels accounts for the bulk of man-made sources of primary air pollutants and their secondary photochemical products - such as ground-level ozone, known to be harmful both to human health and vegetation. In addition to the major stationary sources (i.e., coal-fired and oil-fired power stations and heating facilities) and mobile sources (i.e., motor vehicles, aircraft and ship engines), a wide range of other industrial processes, consumer products and agricultural practices contribute to the overall emissions inventory.

15. Effective technologies to control and reduce most of these emissions at source or at end-of-pipe are available, at least for the majority of new emission sources, but in view of their additional financial and/or energy costs require regulatory coercion or economic incentives to be applied. The same is true for a number of available alternative concepts of energy use and energy savings. While air pollution strategies initially preferred "high stacks" to achieve wide dispersion, most countries have now realized the shortsightedness of this approach and have begun to control and reduce emissions. Information on available cost-effective technologies is regularly exchanged through international programmes and meetings - e.g., the 1991 Nuremberg Seminar on Emission Controls for Stationary Sources, organized by

the United Nations Economic Commission for Europe - although the focus tends to be on technological requirements of developed rather than developing countries.

16. Internationally comparable information is available on emission control costs for stationary and mobile air pollution sources, especially within the framework of the Geneva Convention on Long-range Transboundary Air Pollution (e.g., the proceedings of the 1987 Esslingen Workshop on Emission Control Costs; and the technical annexes of the 1988 Protocol on Nitrogen Oxides and the 1991 draft protocol on volatile organic compounds), as well as on the effectiveness of economic instruments for air pollution control (in UN/ECE Air Pollution Studies No. 7, ECE/EB.AIR/26, 1991; and in the TRACK database developed by the Organisation for Economic Co-operation and Development in 1991). Also in the context of the Geneva Convention, a "Group of Economic Experts on Air Pollution" has undertaken extensive work on cost-benefit analysis and integrated assessment modelling for air pollution control measures, in collaboration with the International Institute for Applied Systems Analysis (IIASA).

II. BASIS FOR INTERNATIONAL ACTION

17. There are currently three types of international instruments to regulate air pollution: overall agreements for transboundary air pollution control and reduction (presently existing at a regional or bilateral level only); sectoral technical standards to control emissions from different sources (global and regional); and ambient air quality targets (global and regional).

Transboundary regimes

18. The 1979 Convention on Long-range Transboundary Air Pollution (in force since 1983), elaborated and administered within the framework of the UN/ECE, is geographically limited to Europe and North America and has been ratified by 31 States and the European Community. In addition to laying down common policy principles - including a commitment to use "the best available technology that is economically feasible" for air pollution abatement - this regional treaty established institutions for permanent co-operation, including annual review meetings of an intergovernmental Executive Body, and provides the legal framework for several joint programmes and specific agreements. It has been supplemented, in particular, by a 1984 Protocol on joint long-term financing of the EMEP monitoring programme (ratified by 30 Parties and in force since 1988); a 1985 Protocol on the reduction of sulphur emissions or their transboundary fluxes by at least 30% (ratified by 20 Parties and in force since 1987); and a 1988 Protocol concerning the control of emissions of nitrogen oxides or their transboundary fluxes (ratified by 18 Parties and in force since 1991). A further protocol on the control of volatile organic compounds or their transboundary fluxes is currently being elaborated and expected to be signed in November 1991; a revision of the 1985 sulphur protocol is in preparation; and future regulation of toxic heavy metals and persistent organic compounds is being considered. The regional action initiated by the 1979 Convention is generally considered successful, with the EMEP monitoring data showing an overall 20% decline of sulphur emissions in the European region over the past 10 years.

19. Other legally binding agreements for transboundary air pollution abatement have been concluded within the sub-regional framework of the European Community (elaborated in a series of enactments, such as the 1988 EEC Council Directive on the limitation of emissions of certain pollutants into the air from large combustion plants), and on a bilateral basis between neighbouring countries in Europe (e.g., Finland-USSR in 1989) and North America (Mexico-United States in 1987, Canada-United States in 1991). While most of the earlier regional and bilateral agreements aimed at a flat-rate percentage reduction of specified air pollutants, the focus of more recent negotiations has been on the determination of agreed "critical loads" as a basis for pollution control measures.

20. In addition, several regional agreements for marine environment protection include among their objectives the abatement of "land-based" air pollution. For the North Sea and Baltic Sea areas, the Parties to the 1974 Paris and Helsinki Conventions declared their intention at ministerial conferences in 1990 to achieve a 50% reduction of atmospheric emissions of specified toxic, persistent and bioaccumulative substances. For the Mediterranean, a technical annex regulating atmospheric pollutants is currently in preparation pursuant to a 1980 Protocol to the 1976 Barcelona Convention. Measures against marine pollution "through the atmosphere" are also envisaged by a 1983 Protocol to the 1981 Lima Convention for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific (in force since 1986); by a Protocol to the 1978 Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution; and by the global Montreal Guidelines for the protection of the marine environment against pollution from land-based sources, adopted by the UNEP Governing Council in 1985.

Sectoral regulation

21. International technical standards for the control of specific emission sources have existed in the automobile sector since 1970. Under a 1958 agreement concerning the adoption of uniform conditions of approval and reciprocal recognition of approval for motor vehicles equipment and parts, concluded and regularly updated within the framework of the United Nations Economic Commission for Europe (ECE), 21 countries apply uniform rules for the licensing of motor vehicles, including certification of compliance with agreed technical criteria determining the emission of gaseous pollutants (hydrocarbons, carbon monoxide and nitrogen oxides). On a sub-regional level, common automobile emission standards have been elaborated (in the form of mandatory regulations and directives) by the 12 member countries of the European Community, and (in the form of voluntary guidelines) by the 8-members "Stockholm Group" of countries. In view of the fact that some of the ECE technical standards are also followed on a voluntary basis by several countries outside Europe (e.g., Australia, New Zealand and Singapore), prospects of global harmonization are currently under discussion.

22. For aircraft engine emissions, the Council of the International Civil Aviation Organization (ICAO) has since 1981 set worldwide uniform certification procedures, by technical annex 16 (II) of the 1944 Chicago Convention on International Civil Aviation. Under this system, ICAO member countries mutually recognize certificates issued in conformity with common

testing standards and emission levels for smoke and gaseous pollutant emissions (hydrocarbons, carbon monoxide, and nitrogen oxides).

23. For air pollution from ships, the Marine Environment Protection Committee of the International Maritime Organization (IMO) established a working group in 1990 to determine target loads and strategies for the reduction of ship-based air pollutants (including sulphur dioxide, nitrogen oxides, volatile organic compounds and ozone-depleting substances) to be laid down in a new annex to the 1973/1978 MARPOL Convention for the Prevention of Pollution from Ships. As regards air pollution from waste incineration at sea, the Parties to the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter decided in 1990 to terminate all marine incineration of liquid noxious wastes by the end of 1991, thereby accelerating and superseding earlier timetables.

24. Atmospheric emissions from municipal waste incineration plants in the European Community are since 1989 subject to uniform "limit values" (for dust, heavy metals, hydrochloric acid, hydrofluoric acid and sulphur dioxide) and concentration limits for carbon monoxide and organic compounds.

25. Technical standards for protection against radioactive air pollution are laid down in the comprehensive "basic safety standards for radiation protection" recommended by the International Atomic Energy Agency (IAEA); in mandatory regional standards adopted by the Council of the European Community under the 1957 EURATOM Treaty; and in the International Labour Organization's 1960 Convention concerning the protection of workers against ionizing radiation.

Air quality targets

26. Several directives establishing "limit values" and "guide values" for ambient air concentrations have been enacted since 1980 by the European Community (especially for sulphur dioxide, suspended particulates, nitrogen dioxide and lead). Global "environmental health criteria" and regional "air quality guidelines for Europe" have been set by the World Health Organization (e.g., for sulphur oxides, suspended particulates, nitrogen oxides, ozone and other photochemical oxidants); though drafted by ad hoc expert groups without formal intergovernmental endorsement, these are now widely used as a yardstick for comparative evaluation of air quality, as illustrated by the annex to the present report.

III. POTENTIAL AREAS FOR ACTION

27. After reviewing the current state of experience in combating transboundary air pollution, there appear to be three major types of gaps: gaps in basic information; gaps in transnational communication and training; and gaps in international governance.

Information needs

28. While voluminous and increasingly reliable information now exists on transboundary air pollution in the European/North American region - both as regards long-range background data, and urban/industrial pollution data and

projections - little or no basic information is available for most third world countries. WMO has repeatedly underlined the most urgent need for more balanced geographical coverage of the Global Atmosphere Watch (GAW) network, by way of further monitoring stations in developing countries, at the priority locations already identified by GAW expert consultations in 1989 and 1991. Extension of the network and upgrading of data quality could be accomplished at comparatively low cost, with the technical equipment for a station to monitor basic GAW parameters (including major air pollutants and most greenhouse gases) estimated at less than $100,000, and a total of 50 or 60 additional stations considered sufficient to bring the network to full capacity. Estimates for substantial improvements in urban air pollution monitoring are substantially lower. Technical assistance will be particularly crucial for the development of reliable and harmonized national emission inventories in developing countries. Following the example of recent joint projects for air pollution monitoring in Eastern Europe, bilateral aid programmes could effectively be used for these tasks and the associated training requirements.

29. A second major information gap concerns the specific ecological sensitivity of areas outside Europe and North America to the risks of acidification and other air pollution effects. The project on "Acid Rain and Emissions in Asia" recently initiated by a consortium of research institutions (co-sponsored by the World Bank, UNEP, ESCAP and the United States Department of Energy) has highlighted the need for data on "critical loads/levels" of pollution in the local ecosystems concerned. A considerable amount of expertise in mapping and modelling of critical loads would be available from the corresponding co-operative programmes already established in Europe and North America.

30. Reliable ground-level measurements of air pollution in representative developing country areas are not only essential for long-term global monitoring and for the verification of model calculations and remote sensing data but also as baseline information in pollution emergencies, as illustrated by the transboundary air pollution release resulting from the 1991 Gulf War. Furthermore, both emission inventories and pollution effects in the tropics and sub-tropics are likely to differ substantially from those in temperate regions, as a result of natural conditions (e.g., local soil composition influencing urban dust pollution in Beijing, Cairo and Delhi, as mentioned in the annex), or because of man-made biomass burning such as seasonal savannah fires or slash-and-burn practices.

Communication and training needs

31. Effective abatement of transboundary air pollution is less constrained by shortage of technological information or know-how than by inadequate international transmission and application of such knowledge. Systematic information exchange on "best available" (state-of-the-art) technologies for control of emissions both from stationary and mobile sources occurs mostly between highly developed countries - e.g., the Parties to the Convention on Long-range Transboundary Air Pollution - with little or no consideration for the special requirements of developing countries. International funding institutions could play an important role in facilitating the participation of

these countries in ongoing information exchanges, following the example of the UNDP/ECE project on "Environmental Planning and Management: Air Pollution".

32. Similarly, it is not the absence of international treaties which prevents concerted action in response to transboundary air pollution in regions outside Europe and North America, but rather a general lack of communication on the subject between the countries concerned. Experience in the UN/ECE region has shown that one of the major factors leading to intergovernmental action for reducing sulphur and nitrogen emissions was the growing scientific consensus among national experts which developed in the course of joint programmes and meetings. As these programmes and meetings are not closed to experts from outside the region, a useful first step could be the participation of technical observers from developing countries, possibly with financial support from international funding institutions or bilateral aid agencies. Furthermore, the programme co-ordinating centres operating under the Convention on Long-range Transboundary Air Pollution could serve as temporary training bases for qualified experts from developing countries, subject to the availability of funding for this purpose.

Governance needs

33. The Montevideo Programme for the development and periodic review of environmental law, adopted by the UNEP Governing Council (decision 10/21 of 31 May 1982), called for the preparation of a global "code of conduct with respect to transboundary air pollution, drawing upon existing regional and bilateral experience". That recommendation has not been followed up, however, and there are indeed reasons to consider possible alternative approaches instead. The positive achievements of transboundary air pollution abatement in Europe and North America may to a large extent be attributed to an advanced degree of regional solidarity and co-operation using existing institutional structures in this region. Rather than attempting to "globalize" the existing Convention on Long-range Transboundary Air Pollution, it would seem preferable (i) to take advantage of the scientific capacity and technical-managerial know-how accumulated under this regional regime, by associating experts from outside the region - for purposes of training, information and technology exchange - with the monitoring and assessment programmes already established in the ECE region; and (ii) to explore the possibilities of setting up similar regional regimes in other areas with transboundary air pollution problems. The identification of such areas or sub-regions for this purpose could be initiated under the auspices of the competent regional bodies of the United Nations (though not necessarily limited by their geographical delineations), taking into account both the substantive range of transboundary pollution in the area concerned and the availability of suitable intergovernmental institutions for co-operation.

34. As evidenced by the number of United Nations bodies and specialized agencies already involved in technical standard-setting for different sources of air pollution in the transport sector (including UN/ECE, ICAO and IMO), there is no dearth of regulatory competences or initiatives in this field. What appears to be missing, however, is a measure of intersectoral co-ordination and harmonization, to avoid inconsistent or conflicting treatment of different transport modes and industries with regard to emission standards, fuel quality standards, etc. This would not require any major institutional

innovation: as an example, uniform technical recommendations on the transport of dangerous goods - applicable to all modes of transport by road, rail, air, sea and inland waters (ST/SG/AC.10/1, 6th revised edition 1989) - have for the past 30 years been laid down through a 15-members Committee of Experts established by ECOSOC Resolution 468 (XV). It would seem appropriate today to look for similar intersectoral guidance on the common technical problems of air pollution generated by all modes of transportation.

35. Given the frequent reference to internationally comparable air quality targets, especially as a basis for the assessment and abatement of urban air pollution, the present system of setting criteria and guidelines by ad hoc WHO expert panels (mostly on the basis of European data) could be expanded to a more permanent intergovernmental level that would also give due consideration to the concerns of developing countries. A group of governmentally designated experts could thus be convened, with technical backstopping from the appropriate United Nations bodies and agencies, to set and periodically review authoritative (albeit non-mandatory) guidelines for ambient air quality. While the primary focus should be on human health risks, including the role of indoor air pollution, critical values for other environmental risks could also be taken into account with due regard to regional differences and priorities.

36. Responses to transboundary air pollution will inevitably impinge on a wide range of other environment and development activities. For example, nitrogen oxides emissions must be controlled locally because of their contribution to the formation of ground-level ozone and urban smog; regionally because of their share in acid precipitation; and globally because tropospheric ozone also acts as a greenhouse gas. International action in this field thus offers a number of multiple-benefits options for decision-making.

ANNEX*

Urban Air Pollution as a Source of Transboundary Air Pollution:
Air Pollution in Megacities of the World

1. Many of the major cities of the world are beset by a series of environmentally related problems not the least of which is their deteriorating air quality. The available information shows that WHO guidelines are being regularly exceeded in major urban areas. Given the rate at which these cities are growing, and the general lack of pollution control measures, the situation will no doubt worsen and the living standards of many urban residents will deteriorate. Although good progress has been made in controlling air pollution problems in many industrialized countries over the last two decades, air quality in large cities of the developing countries is deteriorating. Comprehensive and urgent action is clearly necessary.

2. In order to address the situation, WHO and UNEP initiated a study of air pollution in twenty of the world's largest urban areas or "megacities". The assessment began in November 1990 and is being based on the air quality data obtained over the years by the WHO/UNEP Air Quality Monitoring Programme, a component of the Global Environment Monitoring System. In addition to information on air quality, data on pollution sources and other indicators were also collected from the authorities of the cities. The assessment will be concluded in October 1991 at a meeting of governmentally designated experts who will review the results and recommendations. The present note summarizes the results obtained to date. It also includes a number of conclusions regarding action by national as well as international agencies. The current assessment clearly shows the lack of reliable information on air pollution and its effects on populations. It is clear that the international community through participation in Earthwatch must fill this gap.

3. For the purpose of this report, megacities are defined as those cities with a current or projected population of 10 million or more by the year 2000. The cities included in the assessment are Bangkok, Beijing, Bombay, Buenos Aires, Cairo/Giza, Calcutta, Jakarta, Karachi, London, Los Angeles, Metro Manila/Quezon City, Mexico City, Moscow, New Delhi, New York City, Rio de Janeiro, Sao Paulo, Seoul, Shanghai, and Tokyo/Yokohama.

4. Although the urban growth rate has slowed in developed cities over the past 20 years, it is projected that all 20 megacities will undergo urban growth into the next century - the South-east Asian and Indian cities having the highest average annual growth rate. The air pollution problems of these cities vary greatly due to a number of factors including geography, demography, climate and the rate of industrialization and socio-economic

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* Prepared by the World Health Organization (WHO and the United Nations Environment Programme (UNEP)). WHO and UNEP have issued two earlier comprehensive assessments: The first, entitled Urban Air Pollution 1973-1980, was published in 1984; the second was conducted in 1988, resulting in the publication, GEMS Assessment of Urban Air Quality.

development. These problems are of increasing importance due to the projected growth in the urban population worldwide and thus the potential increase in the number of people exposed to air pollution. United Nations estimates (Prospects of World Urbanization, 1988) indicate that by the year 2000, 47% of the global population will be living in urban areas. The issues raised apply not only to current megacities, but to all rapidly developing urban areas.

Sources

5. The combustion of fossil fuels to generate electricity and to provide power for industrial processes leads to the production of sulphur dioxide, oxides of nitrogen, primary particulates (natural dusts, fly ash, soot) and secondary particulates (ozone and acid aerosols). Domestic solid fuel use, mainly coal and wood, may also significantly contribute to pollutant emissions in some cities. Motor vehicles are now a major factor influencing air quality in cities throughout the world. Petrol-driven motor vehicles are the principal source of carbon monoxide, oxides of nitrogen and hydrocarbons. It is emissions of these primary pollutants that play an important role in the formation of secondary photochemical oxidants such as nitrogen dioxide and ozone.

Long-range transport

6. The long-range transport of urban air pollutants results in impacts on a national and regional scale. Urban emissions of nitrogen and sulphur oxides may contribute to acid deposition at great distances from the source. Projected increases in urbanization, industrialization and motorization, and the associated increase in emissions, would suggest that megacities and other rapidly developing urban areas will become an important source of transboundary pollution.

Health effects

7. The human health effects of air pollution vary according to the intensity and duration of exposure and the health status of the population exposed. The level of exposure may be influenced by many factors such as climate, nutrition, quality of housing, smoking, occupation, etc. Certain members of the population may be at greater risk, for example, those suffering from respiratory and cardiopulmonary disease, pregnant women, young infants and the elderly, hyper-responders and people exercising. Increased mortality, morbidity and deficits in pulmonary function has long been associated with annual and daily mean sulphur dioxide and suspended particulate matter concentrations above WHO guideline values.

8. Motor vehicle emissions cause a wide range of health effects. Carbon monoxide has a high affinity for haemoglobin and is able to displace oxygen which may have cardiovascular and/or neurobehavioural effects. Nitrogen dioxide and ozone often act synergistically and acute exposure can cause inflammatory and permeability responses, lung function decrements, increases in airway reactivity, and general respiratory symptoms. Lead is believed to cause blood enzyme changes, anaemia, hyperactivity and other neurobehavioural effects.

SUMMARY OF RESULTS OF THE ASSESSMENT TO DATE

Sulphur dioxide

9. GEMS/Air data, together with data from national and local authorities, show that sulphur dioxide concentrations have decreased in line with emissions in many of the megacities. This trend has been largely brought about by changes in industrial and domestic fuel use. In some cities, such as London, New York City and Sao Paulo, "clean air" legislation has forced industry and domestic users to switch from high sulphur coal and oil to less directly polluting fuel such as electricity and natural gas. In other cities, e.g., Bombay, the change has been brought about largely by economic benefits.

10. Alternatively, several cities show an increasing trend in annual sulphur dioxide concentrations and emissions. For example, increasing emissions in Delhi are mainly as a result of rapid industrialization. Beijing and Shanghai are almost totally reliant on coal for electricity generation and as an industrial and domestic fuel; therefore, annual average concentrations regularly exceed WHO guideline values. Alternatively, in Bangkok and Sao Paulo a large proportion of sulphur dioxide emissions are attributed to transport.

11. Despite reductions in annual average concentrations, urban sulphur dioxide levels show marked seasonal and diurnal variation. Short-term guideline exceedences often occur corresponding with temperature inversions and cold winter conditions. These pollution "episodes" may still pose a significant risk to health, causing increases in mortality and respiratory illness. High pollution episodes may involve a number of pollutants (i.e., sulphur dioxide, nitrogen dioxide, carbon monoxide) which act synergistically, intensifying health effects.

Suspended particulate matter

12. Trends in suspended particulate matter are similar to those observed for sulphur dioxide in industrialized cities such as New York City and London. Once again, changes in fuel use have influenced both emissions and ambient concentrations. Suspended particulate matter emissions have fallen in these cities despite an increase in power generation from coal. Generating capacity has generally shifted out of the cities and more efficient combustion techniques with particulate removal equipment have been introduced. Coal washing and the introduction of smokeless fuel have also helped to reduce emissions.

13. The situation in many of the developing megacities is very different, mainly due to rapid industrialization. The economic benefits to both cities and nations associated with industrialization often out-weigh environmental concerns.

14. Considerable concern has been raised worldwide with regard to smoke emissions from diesel vehicles. This source can account for up to 70 per cent of suspended particulate matter (smoke) emissions in some cities. Most emissions estimates and projections show an increase in respirable particulates attributed to diesel vehicles, due to their increasing popularity

combined with a lack of adequate control legislation. This is of particular concern due to the carcinogenicity of certain smoke constituents, e.g., polycyclic aromatic hydrocarbons.

15. Several of the megacities are characterized by very high natural dust levels which influence suspended particulate matter concentrations. Beijing, Delhi and Cairo are examples of cities where local soil characteristics and climate greatly influence urban suspended particulate matter levels.

Oxides of nitrogen

16. The principal sources of oxides of nitrogen in urban areas are fossil fuel combustion and, increasingly, motor vehicle transport. Each category accounts for between 1/2 and 1/3 of all oxides of nitrogen emissions in most cities. Nitrogen dioxide is of greater potential risk to health than nitric oxide as it is a respiratory irritant. Oxides of nitrogen are also important precursors of secondary photochemical pollutants such as nitrogen dioxide and ozone.

17. Analysis of nitrogen dioxide data for the megacities assessment reveals that ambient concentrations are increasing in virtually all urban areas. The correlation between elevated oxides of nitrogen concentrations and motor vehicles has been clearly demonstrated by wide-scale (distribution) monitoring in London and Los Angeles. The most heavily congested areas and major transport corridors show the highest annual average concentrations. Nitrogen dioxide, like other urban air pollutants, is affected by local topography and meteorological conditions.

18. Effective oxides of nitrogen control measures have, to a large extent, been countered by the phenomenal increase in motor vehicle transport. Even in cities where strict emissions controls have been imposed on mobile and stationary sources, such as in United States cities and Tokyo, levels have only stabilized, largely as a result of the increase in traffic. Effective oxides of nitrogen controls for stationary sources (e.g., catalysts) are already employed in many industrialized countries and the distribution and refinement of this technology should be encouraged wherever possible.

19. In order to reduce oxides of nitrogen emission, alternatives to fossil fuel are required. Promotion of public transport, especially in cities, and a switch to alternative fuels for personal transport will help. In the short term, improved road planning would also help to reduce exposure.

Ozone

20. Ozone data are less widely available than for other pollutants. Cities, such as Los Angeles and Mexico City, which have high motor vehicle populations and the necessary meteorological conditions tend to experience the worst ozone episodes. Ozone formation is a photochemical process and is dependent upon solar radiation and emissions of oxides of nitrogen and volatile organic compounds, chiefly from motor vehicles. Exceedances of national and WHO guideline levels are a regular occurrence in Los Angeles, Mexico City and Sao Paulo throughout the year.

21. Little is known about ozone concentrations in the cities of developing countries, as there have been few studies or monitoring programmes. Considering the high increase in oxides of nitrogen and volatile organic compound emissions in many of the megacities (e.g., Delhi, Bombay) associated with increasing road traffic and favourable meteorological conditions, it is likely that ozone will play an increasingly important role in the future. Ozone control is to a large extent dependent upon the control of oxides of nitrogen and volatile organic compounds.

Carbon monoxide

22. It is widely accepted that emissions of carbon monoxide have risen in line with the growth of motor vehicle numbers and mileage in recent years. The introduction of stricter mobile emissions control legislation and more efficient engines in many developed countries have helped to reduce or stabilize ambient carbon monoxide concentrations in many cities, most notably, Tokyo, New York City, Los Angeles and London. Once again, in the cities of many developing countries trends are less obvious due to the lack of monitoring. Emissions inventories suggest that the carbon monoxide emissions from motor vehicles are increasing in a similar way to oxides of nitrogen and this is reflected in studies on average concentrations and human exposure. Even where average urban levels are falling, elevated kerb-side carbon monoxide concentrations are of major concern, due to direct exposure of people at the road side.

23. The issues surrounding carbon monoxide control are similar to those for oxides of nitrogen and ozone as motor vehicles are the main source, especially in terms of direct human exposure. In the short term, the introduction of emissions control legislation similar to that in force in the United States, Japan and Europe may help to stabilize emissions.

Lead

24. Exposure to lead from mobile sources is important in those developing countries where tetra-alkyl lead is still a major fuel additive. Levels of tetra-ethyl lead in petrol have been reduced and even phased out in many developed countries and this is reflected in the ambient airborne lead concentrations of Tokyo, New York City, Los Angeles and London.

PRELIMINARY CONCLUSIONS

(a) The air pollution problems in most of the megacities of the developing countries are severe and there is every indication that they will get worse with continued urbanization.

(b) There are notable improvements with respect to certain pollutants in many of the cities of developed countries; however, this is not always the case. For example, oxides of nitrogen and ozone remain a problem despite stringent controls in some countries.

(c) More specifically, sulphur dioxide concentrations have been decreasing in most of the cities. However, in those developing cities reliant on coal as a fuel, levels remain unacceptably high. This is also true for

suspended particulate matter. Emissions of suspended particulate matter from diesel vehicles are of increasing concern. Trends in oxides of nitrogen concentrations are generally upward or stationary at best. Information on ozone concentrations is limited, but where it is available, regular exceedances of health guidelines are shown. Increasing motor vehicle emissions, particularly in developing countries, are giving rise to increases in carbon monoxide and lead levels. In many developed countries, lead levels are decreasing due to the phasing out of leaded petrol.

(d) There are still major difficulties in assessing the adverse health effects of urban air pollution due to lack of information on actual human exposure. This is particularly true in the cities of developing countries where socio-economic factors, climatic conditions, etc. are very different from those areas where such research has been conducted. The scarcity of human health data has, no doubt, contributed to the lack of appreciation of the severity of air pollution problems in these cities and thus to the lack of positive action.

(e) The national capabilities for the assessment and management of air pollution problems in most countries are grossly inadequate.

The assessment, when completed, will propose a series of actions which need to be addressed by national governments. These are expected to include:

(i) Relevant international organizations participating in Earthwatch must play an active role in supporting governments in building up and/or strengthening their monitoring and assessment capabilities and in establishing causal relationships and management alternatives.

(ii) In order to reverse the trends currently observed, stringent emission control strategies should be applied to all new industrial developments.

(iii) Urban air quality can be greatly improved by the implementation of innovative development schemes, e.g., better mass transit, combined heat and power stations, better treatment of waste, and urban planning.